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THE GEOLOGY OF SWITZERLAND TOWNSHIP, MONROE COUNTY, OHIO[1]

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The aim of this report is twofold. It is primarily an attempt to summarize the geologic events that transpired in the past as interpreted from the exposed rocks in Switzerland Township, the Ohio River valley, and in the broader region of Ohio, West Virginia, and Pennsylvania. Secondly, this report summarizes the structural and economic geology of Switzerland Township and immediate environs.

HISTORY AND ECONOMIC SETTING OF SWITZERLAND TOWNSHIP

In April 1819, ten German and Swiss families embarked on a flat boat on the Aar River enroute to Berne, Switzerland, and thence on the Rhine to Antwerp, Belgium. After 48 days aboard the Eugenius, a French vessel bound for New York, they landed at Amboy, New Jersey. Six families purchased teams for the overland trek to Wheeling, West Virginia. At the mouth of Captina Creek at the present site of Powhatan Point, Ohio, they found two Pennsylvania Dutch men who informed them that there was plenty of government land in Monroe County, Ohio. On September 15, Father Tischer and part of his band continued down river 15 miles to Bare's Landing, Ohio Township, and the remainder settled in the hills above Powhatan Point. Switzerland Township, an area of about 28 square miles, was organized by the latter group January 1, 1827.

These early settlers selected a small portion of the maturely dissected Allegheny Plateau (fig. 1) as the site for their new home. To the casual early Swiss observer, the hilly topography of his new home was reminiscent of Switzerland, especially the seemingly never-changing, impenetrable landscape. It is only necessary to walk in the numerous ravines, especially during the spring of the year, or to follow them to their confluence with a larger stream to observe the large amount of rock debris of all sizes and shapes being eroded and undergoing physical and chemical weathering on its route to the sea. Although other eroding forces are at work, running water is the dominant force removing debris from the slowly ever-changing landscape in those "everlasting hills."

The early economy of Switzerland Township was centered around the small cheese and dairy industries located on the divides and high in the heads of valleys. The agricultural economy was supplemented by utilizing some of the thicker beds of poor quality coal, and the limestone and sandstone outcropping in the steep valleys. In the early days transportation was primarily by steamboat on the Ohio River. In later years, the recovery of oil and gas and high grade coal from

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beneath the surface rocks, and the utilization of the industrial water of the Ohio River and its terraces here and in the near vicinity have contributed to this economy.

DESCRIPTION AND ORIGIN OF THE ROCKS OF SWITZERLAND TOWNSHIP AND ENVIRONS

Origin of rocks. The amateur student of earth science as well as the professional geologist can obtain a better understanding of the history of the earth by closely observing the outcropping rocks in the ravines and roadcuts. For it is only the

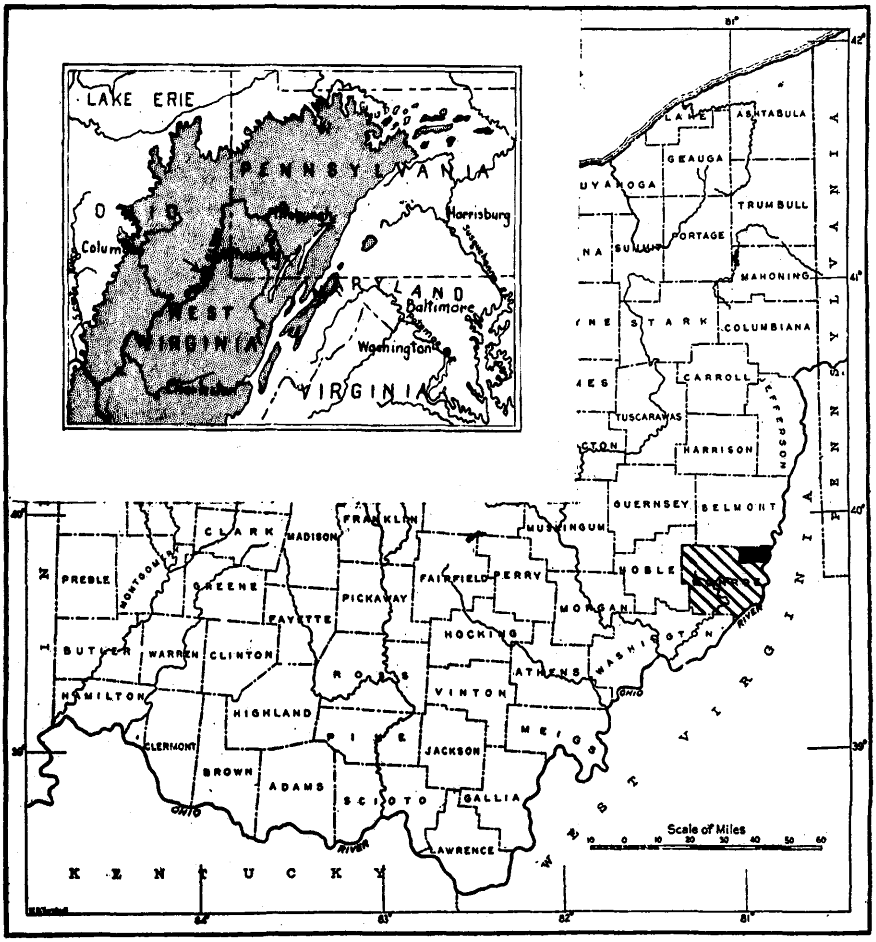


FIGURE 1. Location map. Switzerland Township and vicinity shown in black. Monroe County is cross-hatched. Inset shows position of Switzerland Township (black) in the northern Appalachian Coal Basin (stippled).

rocks themselves that relate the story of the life that flourished and the environmental conditions that existed during their deposition.

Throughout the entire region where coal occurs, the layers of rock are of sedimentary origin. That is, they are made up of sediments such as sand, silt, and clay, derived from weathering of previously formed bedrock, or unconsolidated sediments which have been transported by wind and water and have accumulated along with calcareous ooze and shells in the lakes and seas and with the peat of the bogs and swamps. These sediments have been compacted and cemented together to form the coal-bearing strata often referred to as the "Coal Measures."

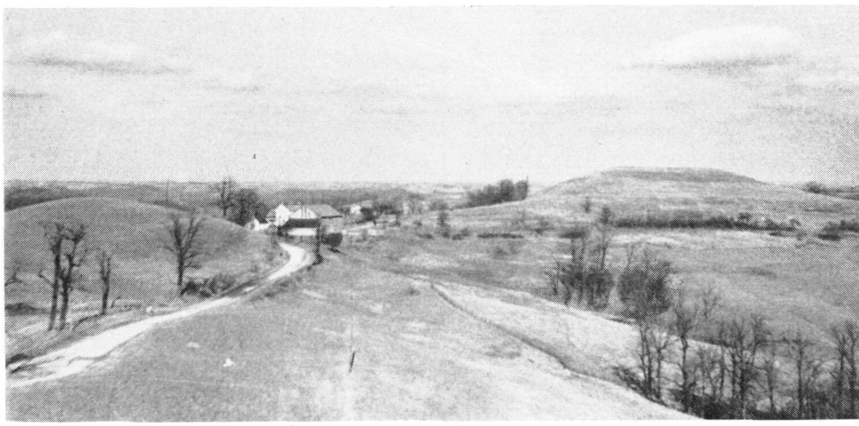


FIGURE 2. View of Dunkard topography from Switzer Schoolhouse (El. 1360!) looking northeastward.

Sequence of layers. In Switzerland Township, and in the rocks of equivalent age throughout most of the Appalachian area (Stout, 1931), there is an orderly repetition of the sequence of various kinds of strata. In the 870 feet of strata exposed in Switzerland Township, 35 cycles of deposition, more or less complete,

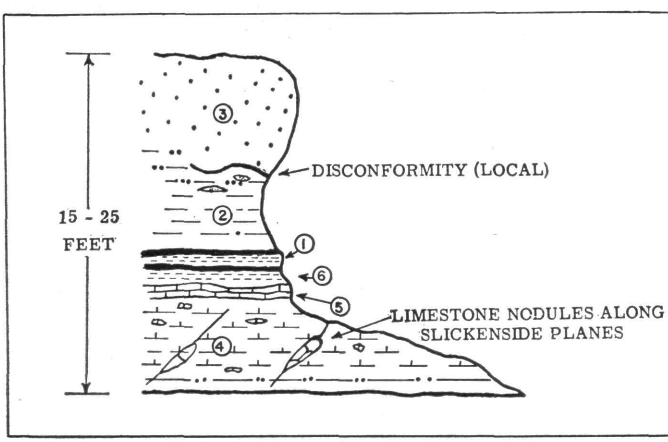


FIGURE 3. Diagrammatic sketch showing the members of an ideally developed cycle of deposition.

averaging 15 to 25 feet in thickness, illustrate the orderly sequence and recurrence of the various kinds of strata. An ideal cycle consists of six members. Beginning with the highest, these members are the following (fig. 3):

(6) Underclay (compacted clay)

(5) Limestone, light gray to dark gray, often nodular (calcium carbonate precipitated by plants and minute organisms, shell fragments, clay, silt)

(4) Shales, calcareous, dusky-red to dusky-yellow, non-bedded, with limestone nodules (compacted silt, clay, and calcareous mud)
(3) Sandstone, fine- to medium-grained, weathers moderate olive-brown
Disconformity (local)—break in deposition
(2) Roof shale, gray to dusky-red, well bedded (compacted silt and clay)
(1) Coal (altered plant remains) and/or carbonaceous shale

As should be expected, many local variations occur laterally even when the cycle is ideally developed, and in many instances one to three of the components may be missing or very poorly developed.

Clay. Nearly always associated with coals, the clays are best developed below the coals, although clay partings occur in the coal, and there are a few examples of a clay above the coal. The clays are normally gray in color and are similar to the shales below except that they are richer in alumina and contain less silt and sand.

In the past, it was thought that the clay represented an old soil which supported plant growth in the coal swamps. Although *stigmaria* (fossil roots) are found in some of the clays, the prevalent belief is that the silts and clay particles were deposited in the coal-forming swamps and were altered by the plants and decaying organic products.

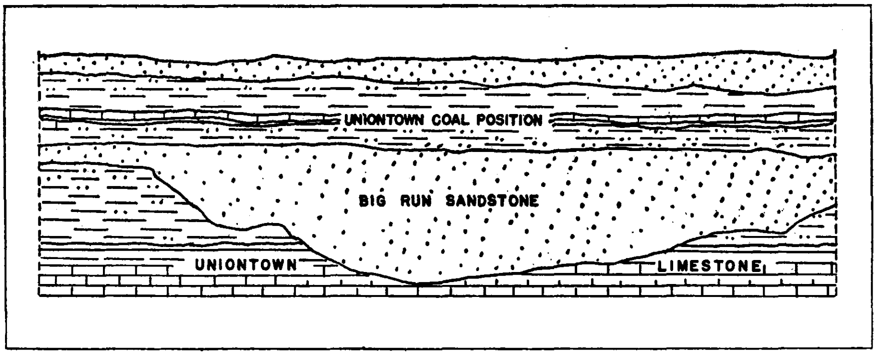


FIGURE 4. Sketch of a channel deposit of Big Run sandstone.

Limestone. The limestones are composed of hard thin-bedded layers with interbedded red and gray shales composed of clay minerals and calcareous ooze ($CaCO_3$), which was possibly precipitated largely by plant life, and varying amounts of silt. Incipiently developed limestone beds are nodular, more or less continuous beds.

Many of the limestones contain fossil remains of small animals, e.g., ostracods (crustaceans), gastropods (snails), pelecypods (clams), *spirorbis* (worm tubes), bone fragments, fish teeth, coprolites (fish excrement), and a few brackish-water brachiopods (lamp shells). It is believed that the faunal assemblage preserved in the limestones lived in fresh-water lakes lying just above sea level which were flooded occasionally by brackish water from the ocean.

Sandstone. Of the rock types, sandstone is the most resistant to the weathering and eroding processes; and wherever it is massively developed, falls, steep-walled cliffs, and amphitheaters in the heads of ravines add to the scenic beauty of the area. The remainder of the rocks decompose and disintegrate readily and unless protected by an overhanging cliff of sandstone, form gentle slopes covered with talus (rock debris) and soil.

Although the sandstones show many depositional features the irregularities at the base of the sandstone are most conspicuous. One of the most notable of the sandstones, the Big Run sandstone (fig. 4), thickens locally to 30 feet, replacing the older rocks below. Outcropping on Ohio Route 7, one mile northeast of Powhatan Point, on Big Run, on Blair Run, and farther south along the Ohio River, the Big Run sandstone appears to have been deposited in an ancient stream channel whose course roughly paralleled the present Ohio River valley.

Roof shale. Resting directly on the coal or coal position is found a thin-bedded olive-gray to dusky-red shale, which on the outcrop is easily distinguished from the poorly bedded shale below the coal by its plate-like character. Toward the base of the roof shale and directly over the coal, the shale often contains well preserved fossil leaf and stem impressions.

GEOLOGIC TIME TABLE

ERAS ESTIMATED DURATION IN YEARS	PERIODS ESTIMATED DURATION IN YEARS	SERIES PRINCIPLE ROCK UNITS EXPOSED IN APPALACHIAN PLATEAU		THICKNESS OF SERIES EXPOSED IN SWITZERLAND TWP.
CENOZOIC 55 MILLION YEARS	QUATERNARY 2 MILLION YEARS			60 FEET
	TERTIARY 53 MILLION YEARS		NOT REPRESENTED IN THE APPALACHIAN REGION	
MESOZOIC 106 MILLION YEARS	CRETACEOUS 55 MILLION YEARS			
	JURASSIC 28 MILLION YEARS			
	TRIASSIC 23 MILLION YEARS			
PALEOZOIC 314 MILLION YEARS	PERMIAN 33 MILLION YEARS	GREENE WASHINGTON		340 FEET 230 FEET
	PENNSYLVANIAN 42 MILLION YEARS	MONONGAHELA CONEMAUGH ALLEGHENY POTTSVILLE		300 FEET
	MISSISSIPPIAN 32 MILLION YEARS		BELOW DRAINAGE IN SWITZERLAND TOWNSHIP	
	DEVONIAN 37 MILLION YEARS			
	SILURIAN 22 MILLION YEARS			
	ORDOVICIAN 79 MILLION YEARS			
	CAMBRIAN 69 MILLION YEARS			
PRE-CAMBRIAN 1300 MILLION YEARS				

FIGURE 5. Geologic time table showing the principal units and thicknesses of rocks exposed in Switzerland Township.

Coal. In general, the area of the fresh-water lakes became swampy and was invaded by land-loving types of plants to form the verdant coal swamps of West Virginia, Pennsylvania, and Ohio.

The coals often vary in thickness laterally and are dependent on the thickness of the decaying plant debris and on the rapidity of deposition and the weight of the overlying sediments.

Of the 35 possible coal positions that exist in the exposed rock section of Switzerland Township, there are twelve bona fide coals. The thin streaks of silty carbonaceous shales often replacing a coal or included in the coal represent finely divided organic debris from the coal swamp.

Summary. Clay, limestone, sandstone, shale, and coal are the rocks exposed in Switzerland Township and environs. They tell of widespread uniform conditions during which vast sheets of sediments were deposited laterally, but in which an ever-changing physical environment is evidenced in a few feet vertically.

SUMMARY OF THE GEOLOGIC HISTORY OF THE APPALACHIAN AREA

To have a clearer understanding of the rocks described in the preceding paragraphs, it is necessary to picture their relation to the names and the age of the major units of the geologic time table (fig. 5). The age of the major time units is based on the degree of disintegration of radioactive minerals, which is the most accurate means of determination available at the present time.

Except for the larger features, little is known of the life or landscape of the pre-Cambrian, which represents three-fourths of all geologic time. The history of the creation and evolution of the earth through this long period is buried beneath younger rocks on all the continents. In the area under discussion, the drill has never penetrated to a depth great enough to reach the basement rock.

From the Cambrian period through most of the Pennsylvanian period, the Appalachian region was occupied by a great seaway trending in a north-south direction. During most of this time, sediments from the land surrounding the trough were deposited in it by the streams flowing across the fringing land surfaces. A mountain range to the east and south, Appalachia, the eroded roots of which underlie the present coastal plain, supplied a great part of the sand, silt, and clay minerals which were lithified by cementation or compaction by the weight of the overlying sediments deposited later. With the subsidence of the trough increasing in proportion to the increased weight of the sediments nearer to the source area, Appalachia, greater thicknesses of rocks are present southeastward than underlie Switzerland Township.

Toward the end of the Mississippian period and continuing into the early Permian (the youngest recorded rocks in the Appalachian area) the seas which were so widespread in the earlier Paleozoic periods began to withdraw in uneven pulsations. A low swampy coastal plain bordered by deltas of the numerous northeastward-flowing, low-gradient, anastomosing streams dominated the landscape. Only occasionally thereafter did widespread incursions of shallow seas occur.

Vegetation flourished on the coastal plain and in the swamps, some of which were many thousands of square miles in area. After the accumulation of many feet of organic debris, viz., tree trunks, twigs, leaves, and decayed plants, chemical action altered the debris to peat which was then buried by vast sheets of sediments, sand, silt, and clay. The weight of the overlying sediments compacted the peat which, with the passage of time, developed into coal.

Sometime after the youngest rocks were deposited and at least partially lithified, during the Permian period, great horizontal forces were exerted from the southeast. The rocks nearest the orogenic center were folded and broken (faulted) forming the ancestral Appalachian mountains. The rocks farthest from the orogenic center were least affected by these stresses. This accounts for the essentially horizontal attitude of the strata in Switzerland Township and vicinity. Most of the structural features encountered in this area are not easily discernible by casual observation. Most of the apparent structures in the rocks are due to depositional irregularities and faulting and folding which occurred almost simultaneously with the sedimentation.

Approximately 160 million years have elapsed since the youngest exposed rocks were deposited, and during this time various erosional processes have been at work. By the beginning of the Cretaceous period the land forms of the ancestral Appalachian mountains had been eroded to an almost level plain when warping of the mountain belt caused the streams to increase their gradient and quicken their erosional pace. At the beginning of the Tertiary period, the streams had again reduced the mountains and hills to a plain, remnants of which are still discernible as the Allegheny Plateau. With little or no folding, the entire area was once more uplifted, this time to a height of nearly one-half mile. The present

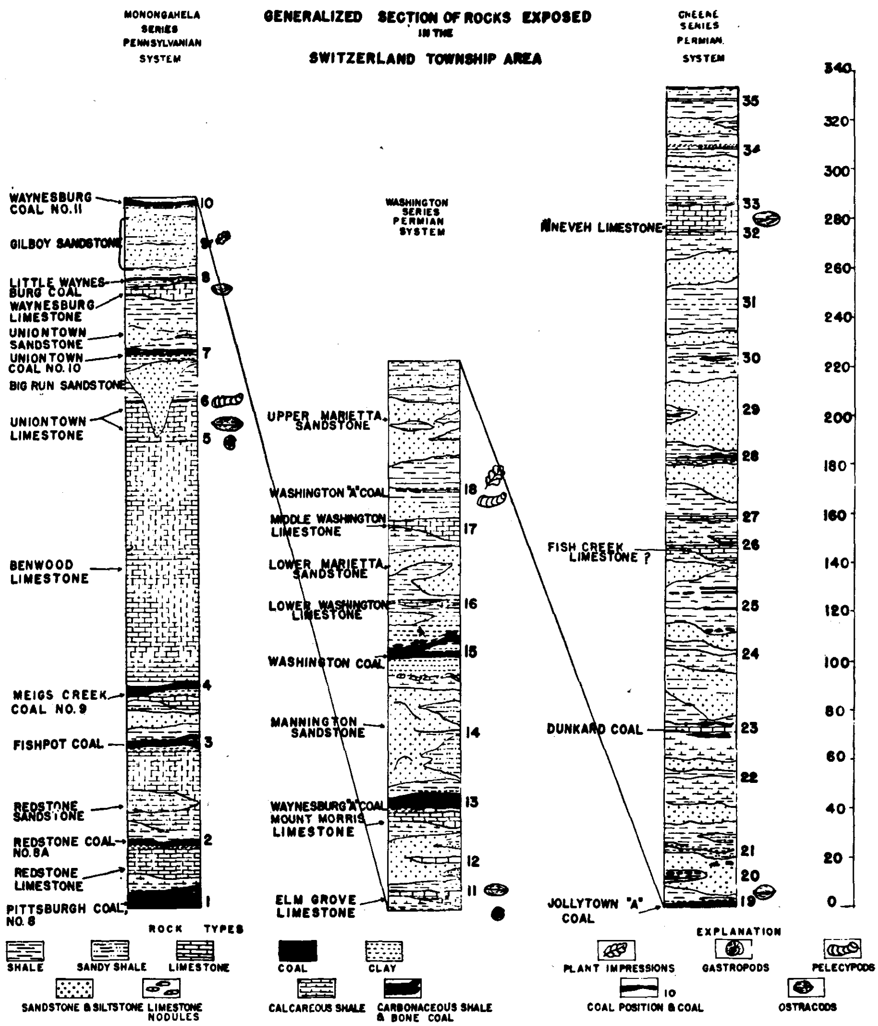


FIGURE 6. Generalized section of rocks exposed in the Switzerland Township area.

ruggedness of the Appalachian area results in the dissection of the Allegheny Plateau by the increased gradient of the streams due to the uplift, but evidence of the old plain is still preserved in the even crests of the high divides and knobs. By the beginning of the Tertiary period, almost 55 million years ago, North America had taken on a fairly modern appearance.

During the Pleistocene period, the occurrence of glaciation in northern Ohio and Pennsylvania was the last catastrophic event affecting the landscape in Switzerland Township and immediate environs. The glaciers blocked the north-flowing ancestral Ohio River, causing a huge lake to form in the valley and its tributaries. It is believed that this lake overflowed southward over a low divide at the narrows near New Martinsville, West Virginia. A new level of stream cutting and the influx of water from the melting glaciers to the north resulted in the present south-flowing Ohio River and its meandering and entrenched tributaries, which are continually undercutting and thus forming the steep walls of this maturely dissected plateau. Unconsolidated sediments from the glacial and recent periods, i.e., clays, sands, and gravels, form the channels, floodplains, and terraces of the Ohio River and its larger tributaries (fig. 9).

ECONOMIC GEOLOGY OF SWITZERLAND TOWNSHIP AND ENVIRONS

Introduction. The region under consideration, including Switzerland Township, and eastern eight sections of Sunsbury Township, Monroe County, and sections 7, 13, 19, and 25 of York Township, Belmont County, comprises an area of about 40 square miles. The area lies to the west of the axis of the Pittsburgh-Huntington coal basin in the southermost portion of the Belmont County field of the Pittsburgh coal.

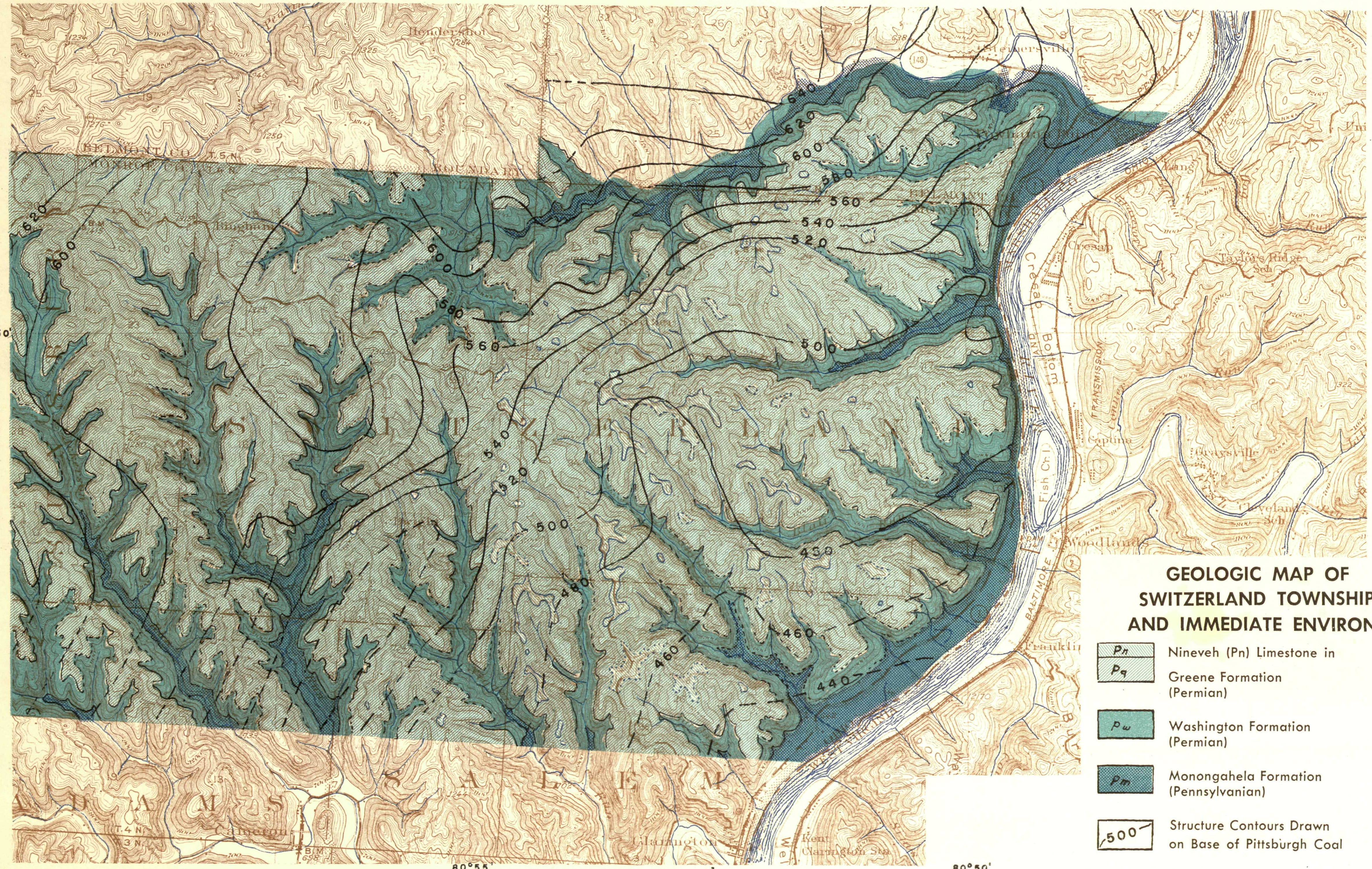
In general, there are few deposits of great economic value except coal in Switzerland Township and vicinity. At the present time only the Pittsburgh coal is being mined, but some of the other coals may ultimately come to be considered economically important as the technologies of synthetic fuels and coal gasification advance. The possibility of developing oil and gas in the area is fair, but little exploration is being carried on now. Many of the limestones have been ground locally for agricultural purposes and as road metal, but no commercial use of the limestone is employed. In the future, a few of the thicker clays may find use in the manufacture of tile and brick.

Stratigraphy. The rocks of the area extend from the Pittsburgh coal, the lowest member of the Monongahela series, Pennsylvanian system, which is exposed on Cat Run in the north, upward to the rocks immediately overlying the Nineveh limestone, a high member of the Greene series, Permian system, exposed on the high ridges in south-central Switzerland Township (fig. 6). The named units above the Washington coal are not necessarily correlative with those of the type locality and will be revised at the completion of the field work being carried on at the present time in the rocks of equivalent age in West Virginia by Dr. Aureal T. Cross.

Structure. The geologic structure of this area is represented on the geologic map (plate I) by contours drawn on the base of the Pittsburgh coal. In areas where well or mine records were not available, the position of the Pittsburgh coal was reckoned by subtracting the normal interval from any higher outcropping key stratum. Since the driller's logs indicate a greater fluctuation of the interval between the key horizons below the Pittsburgh coal, modifications would be necessary to show the true features of the oil-bearing strata.

In general, the rocks have a comparatively simple structure. In addition to the gentle undulations of individual beds due to irregularities of the surface during deposition, a regional dip of 30 feet per mile in a southeast direction is probably due to a combination of down-warping of the trough to the east during deposition, with a subsequent regional flexure at a later time.

In the southeast, a structural terrace rises rapidly to form a ridge which trends northeast across the center of the area. In York Township, Belmont County, an anticlinal nose is shown which may be the southeastward extension of the Jacobsburg anticline, described by Stout in his unpublished report on the Monongahela series of Ohio.



GEOLOGIC MAP OF SWITZERLAND TOWNSHIP AND IMMEDIATE ENVIRONS

Pn / Pg — Nineveh (Pn) Limestone in Greene Formation (Permian)

Pw — Washington Formation (Permian)

Pm — Monongahela Formation (Pennsylvanian)

500 — Structure Contours Drawn on Base of Pittsburgh Coal

BROKEN LINE INDICATES LACK OF DATA

Scale $\frac{1}{62500}$

1 ½ 0 1 2

Contour interval 20 feet

Base from U. S. Geological Survey Topographic Maps

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JOHN H. MELVIN, Chief

GEOLOGY BY THOMAS ARKLE, JR.
DRAFTING BY RICHARD TURNER

Oil and gas. In 1887 the first well in the area was drilled on Ackerson Run, Adams Township, north of the village of Cameron (Bownocker, 1903). The greatest drilling activity took place between 1887 and 1910, with only an occasional test well since that time. Although there is no record showing the actual number of wells or their production figures for this area, most of the oil in Monroe County was produced from Keener and Big Injun sands, and the available logs of this area indicate production from these sands. According to the residents, many wells came in at 25 barrels per day and were abandoned when production dropped to 10 barrels per day, because of the low price of oil. At the present time, the only producing wells are on Stillhouse and Johnson Runs.

The East Ohio Gas Company has made available a map which shows the location of approximately 100 wells for which only a few driller's logs are available at this time. At least 80 of these wells are grouped in small fields on the extreme eastern, southern, and western fringes of the area. They are generally located low in the valleys which permit drilling of lesser depths to pay sands.

Although the few scattered well logs are lacking in conciseness because the lens-like nature of the sands is not usually recognized by the driller, the information indicates that the area is one in which the prospector can hope to find some oil in one or more of several sandstones, all of which have produced in the past. The known producing sands are below the Pittsburgh coal, and in ascending order they are the Berea, the Big Injun, the Keener, and the Cow Run.

In the future the Berea sand may become an important source of oil, although few wells have penetrated it. The Berea sand is generally a shaly sandstone, 20 feet thick, resting 1600 to 1650 feet below the Pittsburgh coal, and since the Pittsburgh interval for all zones below the "Big Lime" is quite variable, the structure contour map on the Pittsburgh is not wholly applicable to the Berea sandstone. Several logs indicate that minor amounts of gas and oil have been produced from the Berea sand on Ackerson Run, sections 27 and 28, Sunsbury Township.

Usually the Keener sand, a 25-foot unit, rests 1100 to 1150 feet below the Pittsburgh coal and is generally separated from the Big Injun sand below, which is variable but attains a maximum thickness of 125 feet, by a thin shale unit. Both the Keener and Big Injun produce oil and appear to lose production in this area because of encroaching salt water.

Above the Keener sand is a limestone with a few sand zones, the driller's "Big Lime" sand, which is very irregular in thickness, varying from 25 to 100 feet. No record of production from the "Big Lime" is to be found in this area.

A sandstone correlative with either the Cow Run or Buell Run sand lies 450 feet below the Pittsburgh coal in section 30, Sunsbury Township. A resident here reported that in 1910 a field of seven wells was producing approximately 15 barrels of oil per well but was abandoned because of the low price of oil.

The relation of structure to the accumulation of oil in this area is not clear, and no attempt has been made to map the structure on the various sands, although the logs indicate that the sands are variable laterally, which may account for the accumulation of oil. William J. Millard of Bristow, Oklahoma, who has analyzed cores quantitatively for evidence of diffusion of oil pools in depth in this area, believes that oil accumulates where porosity and permeability are favorable regardless of structure. In a personal communication with the author in 1949 he stated, "I am of the opinion that untapped pools remain in the area under consideration where oil and gas will still be found in commercial quantities. Since the depth of drilling is not great and the gravity of the petroleum is light, the small independent producers should be attracted."

Coal. Of the thirty-five possible coal zones illustrated in figure 6, only eight can ever be considered as of potential economic importance in the Switzerland Township area. Below drainage, except along the lower reaches of Captina Creek and Cat Run in York Township, most of the area is underlain by the lower Monongahela series coals, which are. in ascending order, the Pittsburgh (#8), the Redstone (#8A), the Fishpot, and the Meigs Creek (#9) (Bownocker and Dean, 1929).

The most valuable resource of the area is the Pittsburgh coal. The drill cores show it to vary from 4½ to 5½ feet of mineable coal which thins in the southwestern part of the area. The coal has been mined by the Powhatan Mining Company, Powhatan, Ohio, throughout most of the northeastern one-third of the area (fig. 7). Another opening was made by shaft at the Marcoll Mine, section 11, Switzerland Township, but it was abandoned following an explosion before any coal was removed. As far as the writer can determine, the remainder of the coal in this area is untouched.

Along the outcrop on Captina Creek and Cat Run, York Township, the Redstone and Fishpot coals have been used for domestic purposes in the past. Underlying most of the area are found the Redstone coal, composed of 1 to 2 feet of bone and coal, and the Fishpot coal, which varies from a mere streak to 3½ feet in

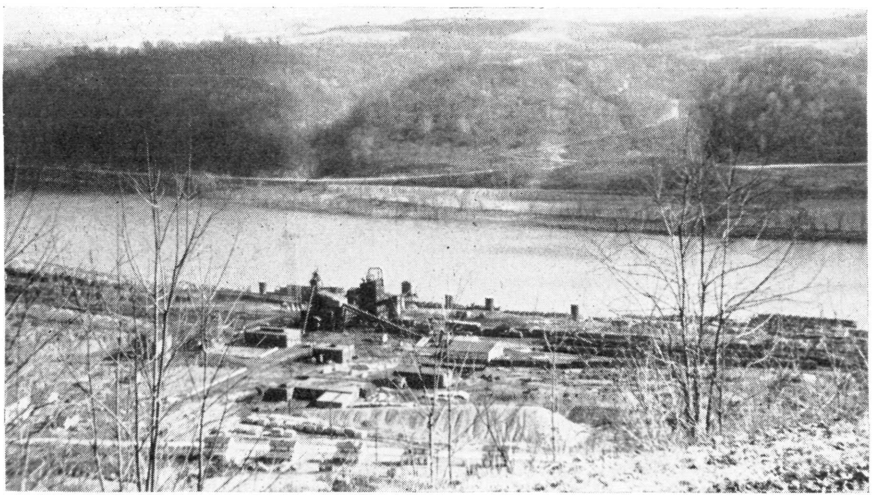

FIGURE 7. View from high in the hills above Powhatan Point showing the Powhatan mine tipple and the Ohio River in the foreground with the hills of West Virginia in the background.

thickness. On Captina Creek the Fishpot coal zone is 7′11″ thick, but it is made up of impure coal containing numerous clay partings and one sandstone parting. This coal is probably of the same character below drainage, but the drill core records are not detailed enough to show this. The partings and the ash content make the Fishpot valueless as a commercial fuel at the present time.

Above drainage on Captina Creek the Meigs Creek coal has been mined for domestic purposes. Below drainage the coal varies from 6 inches to 4½ feet, and it is present in all the drill cores available. In the vicinity of the Marcoll mine shaft, the core logs indicate four feet of coal. There is a possibility that this coal will be mined at this location in the future. The coals of the upper Monongahela and lower Washington series are above drainage in all the major valleys. They are usually multiple, thin-bedded, thick coal zones which, excepting the Washington coal, vary considerably in thickness laterally. In ascending order these coals are the Uniontown (#10), the Waynesburg (#11), the Waynesburg "A," and the Washington.

In the southern part of the area the Uniontown coal varies from 2 to 2½ feet and is split by two or three shale partings toward the base. It is being mined for domestic use on a small scale along Sunfish Creek and its north-heading tributaries. Low in the valleys throughout most of the northern portion of the area, surface outcrops show a few carbonaceous streaks in the Uniontown coal position.

In the area of this report, the Waynesburg coal is not mineable as a commercial fuel, but in the valleys tributary to the Ohio River it is of sufficient thickness to be mined for domestic uses. Just south of the Belmont-Monroe county line, it is one foot thick and rapidly thickens to 3 feet northward. Farther north in Belmont County the Waynesburg coal has been mined commercially.

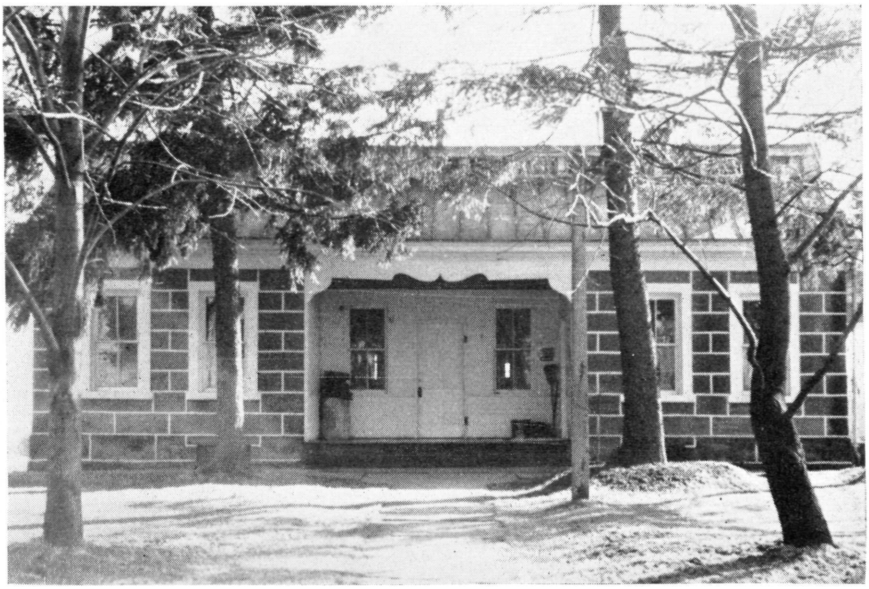

FIGURE 8. View of Wm. Kindleberger's house, constructed from a high Greene series sandstone.

The Waynesburg "A" coal is present everywhere throughout the area, varying from 1 to 5 feet in thickness, but its high ash content and numerous partings limit its use as a commercial fuel. In general the maximum development of the Waynesburg "A" coal lies in a small oval-shaped field that trends northwestward from Nigger Run across the center of the area. In the past the coal was mined only for local purposes, but in the future a thick carbonaceous unit of this type may be useful as a synthetic fuel.

Throughout the area, the Washington coal is everywhere present in good development. It is generally divided into two benches by a clay parting which varies from 3 to 6 inches. In northeastern Switzerland Township, the parting thickens to 7 feet of clay and carbonaceous shale. The coal varies from 4 to 6 feet thick, but the lower bench, usually 1½ feet thick, is generally the best coal. The upper bench is usually comprised of interbedded shale and coal. The coal has been mined extensively for local use in the past and may be useful in the future in the synthetic fuels program.

Limestone. In the section exposed in Switzerland Township and environs there are numerous thin-bedded limestones. The principal ones in ascending order are the following: Fishpot, Benwood, and Uniontown limestones, which are thicker units (10 to 50 feet); and Elm Grove, Mount Morris, Lower and Middle Washington, and a number of high thin multi-bedded limestones, including the Nineveh limestone toward the top of the Greene series, which are generally thinner units. Farmers report that they have used these limestones for agricultural purposes but with little success, since they are generally high in magnesium and low in calcium. Tests have been made of the Fishpot, Benwood, and Uniontown limestones at Armstrongs Mills, Washington Township, just north of the area, and the information at hand indicates that the uses to which the limestone of the Monongahela series may be put at the present time are few. Condit (1923) says:

> "None of the beds can be of much use for building. Most of the rock when burned for building lime gives an undesirable gray-blue color. The material does not seem promising for use in the manufacture of Portland cement."

In the rock section, the highest well-developed limestone, the Nineveh, lies just beneath the highest knobs in the eastern part of the area and is important in the formation of the fertile soil on which apples, corn, and alfalfa are grown. Tests to the south of the area of this report show the limestone to be 85 percent

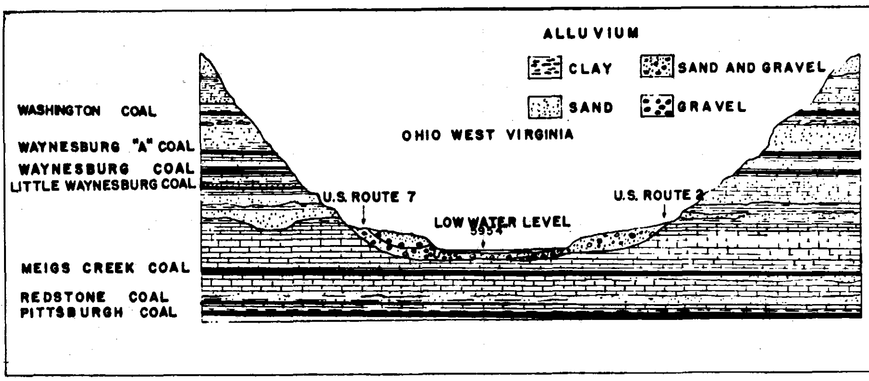

FIGURE 9. Cross-section of the Ohio River valley showing alluvium at Dam #14, north of Clarington, Ohio.

calcium carbonate and in certain zones to be as high as 95 percent. Although the rocks could be easily removed, few farmers have quarried the Nineveh limestone in recent years. Where suitably located, a number of the limestones have been used for road metal on state, county, and township roads.

Clay. Since most of the clays are thin or wanting, except that associated with the Washington coal, little interest in the clay has been shown. The thick clay above and below the Washington coal may be suitable as an aggregate for the manufacture of brick and tile in the future. Generally it is high in the hills at the valley mouths, and at present it is inaccessible at the points where it goes below drainage toward the valley heads. At the present time, the Marietta Silo Company, Marietta, Ohio, 60 miles south of the area of this report, has been quite successful in using a clay interpreted as being equivalent in the manufacture of their products.

Sandstone. The sandstones were important in the early construction of foundations, and one farmer, William Kindleberger, quarried one of the high Greene series sandstones for the construction of his house and barn (fig. 8). Deposits of sandstone throughout Switzerland Township are plentiful, but unless new uses for iron-stained, thinly laminated, friable sandstones are found, there is little chance of their future development. Although there are no active sandstone quarries at the present time, the sandstones could be used as road metal on secondary roads.

Alluvium. The Ohio River floodplain and terraces bordering this area on the east are narrow but do contain clay, sand, and gravel. Bore holes at Dam #14 show that the floodplain of the river, including the various islands and bars, are composed of some boulders, gravel, coarse and fine sand, clay, and muds (fig. 9). In general, the sediments become coarser downward. Further prospecting would be necessary to show the areal extent of economically valuable deposits.

Alluvium is a reservoir for ground water and in the past has been extensively drilled for drinking water supplies. Since a ready source of water from the Ohio River and its larger tributaries is ever present in large quantities, the alluvium should be prospected for industrial water to be utilized by the rapidly expanding industries of the lower Ohio River valley.

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